DOCUMENT RESUME

ED 396 967 SE 058 740

TITLE	Systemic Engineering Education Reform: An Action Agenda. Recommendations of a Workshop Convened by the NSF Engineering Directorate.
INSTITUTION	National Science Foundation, Arlington, VA. Directorate for Engineering.
REPORT NO	NSF-96-63
PUB DATE	95
NOTE	24p.
AVAILABLE FROM	National Science Foundation, Engineering Directorate, 4201 Wilson Blvd., Arlington, VA.
PUB TYPE	Collected Works - Conference Proceedings (021)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	*Educational Change; *Engineering Education; Higher Education

ABSTRACT

This document is a product of the workshop convened by the National Science Foundation Engineering Directorate. The 43 participants representing industry, government, education, private foundations, professional societies, and the Engineering Deans Council were charged to accept as given the consensus reflected in the reports of the past ten years on the desired characteristics of 21st Century engineering education, recommend steps to achieve these characteristics, and identify the change agents responsible for each step. Key consensus recommendations resulting from three days of deliberation are listed in this document. Appendices include a description of the workshop process, a list of recommendations, 3 one-page background papers, the workshop schedule, and a list of participants. (JRH)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED 396 967

SYSTEMIC ENGINEERING EDUCATION REFORM: AN ACTION AGENDA

Recommendations of a Workshop Convened by the NSF Engineering Directorate

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
This document has been reproduced as received from the person or organization originating it.
☐ Minor changes have been made to improve reproduction quality.
• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

BEST COPY AVAILABLE

General Information

The Foundation provides awards for research in the sciences and engineering. The awardee is wholly responsible for the conduct of such research and preparation of the results for publication. The Foundation, therefore, does not assume responsibility for the research findings or their interpretation.

The Foundation welcomes proposals from all qualified scientists and engineers and strongly encourages women, minorities, and persons with disabilities to compete fully in any of the research related programs described here. In accordance with federal statues, regulations, and NSF policies, no person on grounds of race, color, age, sex, national origin, or disability shall be excluded from participation in, be denied the benefits of, or be subject to discrimination under any program or activity receiving financial assistance from the National Science Foundation.

Facilitation Awards for Scientists and Engineers with Disabilities (FASED) provide funding for special assistance or equipment to enable persons with disabilities (investigators and other staff, including student research assistants) to work on NSF projects. See the program announcement or contact the program coordinator at (703) 306-1636.

The National Science Foundation has TDD (Telephonic Device for the Deaf) capability, which enables individuals with hearing impairment to communicate with the Foundation about NSF programs, employment, or general information.

To access NSF TDD dial (703) 306-0090; for FIRS, 1-800-877-8339.

Any opinions, findings, conclusions, or recommendations expressed in this report are those of the participants and do not necessarily reflect the views of the National Science Foundation.

SYSTEMIC ENGINEERING EDUCATION REFORM: AN ACTION AGENDA

Recommendations of a Workshop Convened by the NSF Engineering Directorate

Renaissance Hotel
Arlington, Virginia
July 11-13, 1995

Irene C. Peden
Edward W. Ernst
Workshop Co-Chairs

John W. Prados
Senior Education Associate
Engineering Education and Centers Division, NSF

In Memoriam

Workshop participants were saddened to learn that F. Karl Willenbrock, a respected leader in the engineering profession and keynote speaker at the Workshop, died on August 24, 1995. Karl's professional contributions included service as Provost at the State University of New York-Buffalo; Director of the Institute for Applied Technology of the National Bureau of Standards; Dean of Engineering at Southern Methodist University; Executive Director of the American Society for Engineering Education; Senior Scientist for the Technology Administration of the Commerce Department; and Assistant Director for Scientific, Technological, and International Affairs of the National Science Foundation. In 1989 he organized and chaired the NSF-sponsored task force that produced the report, *Imperatives in Undergraduate Engineering Education: Issues and Actions*, known as the "Belmont Report." The task force recommendations became the basis for a major NSF investment in systemic reform of undergraduate engineering education through establishment of the Engineering Education Coalitions. Those of us who labor for engineering education reform will miss Karl's leadership, his wisdom, and his friendship.

Table of Contents

Introduction 1

Key Recommendations 2

The Action Agenda 2

Next Steps 2

Acknowledgment 3

Appendix A: Selected Engineering Education Publications, 1985-1995 4

Appendix B: Workshop Process and Aggregate Recommendations 5

Appendix C: Background Materials 8

Appendix D: Workshop Schedule 11

Appendix E: Workshop Participants 13

Introduction

Today's engineering students will spend most of their careers in the 21st Century, coping with challenges and opportunities vastly different from those most currently-practicing engineers have faced in their professional lives. The shift from defense to commercial competition as a major driver for engineering employment; opportunities offered by intelligent technology to be more creative and "work smarter," an expanding social infrastructure that demands a talent for complexity; an eclectic, constantly-changing work environment calling for astute interpersonal skills; and massively integrated populations placing environment, health, and safety at the front end of design will require engineers whose intellectual skills include, but extend well beyond, the traditional science-focused preparation that has characterized engineering education since World War II. Progressive industry leaders and far-sighted educators urge refocusing engineering education to emphasize the intellectual skills needed by the practicing engineer of the 21st Century.

Multiple reports over the past ten years, listed in Appendix A, show remarkable consistency in the attributes they recommend for the new breed of engineering graduates. They also agree that systemic change in engineering education will require a concurrent change from the predominant engineering school academic culture based on compartmentalization of knowledge, individual specialization, and a research-based reward structure to one that values integration as well as specialization, teamwork as well as individual achievement, and educational research and innovation as well as research in the engineering sciences. To enable such a culture change is undoubtedly the greatest challenge facing engineering education reform.

As a catalyst for future action, the NSF Engineering Directorate convened a workshop in July 1995 with the theme, *Systemic Engineering Education Reform: An Action Agenda*. The 43 participants representing industry, government, education, private foundations, professional societies, the Engineering Deans Council, and ABET were charged to accept as given the consensus reflected in the reports of the past ten years on the desired characteristics of 21st Century engineering education; to recommend steps to achieve these characteristics; and to identify the change agents responsible for each step. They were urged to keep in mind three questions: What? How? Who?

Key consensus recommendations resulting from three days of deliberation are listed in the following section. A description of the workshop process and a "long list" of recommendations appear in Appendix B. The participants received three one-page background papers; these appear in Appendix C, the workshop schedule in Appendix D, and a list of participants in Appendix E.

Key Recommendations

The Action Agenda

In summary, the workshop participants recommended:

1. That a broad segment of faculty be involved in the discussion and implementation of this action agenda for systemic engineering education reform. This involvement should be stimulated and led by engineering deans, but other approaches should be explored for motivating and realizing faculty participation.

2. That NSF encourage proposals for programs in which faculty and institutions adopt, adapt, and institutionalize successful educational innovations, including transition to full institutional support by the end of the funding period.

3. That NSF fund collaborative development and use of a nationwide infrastructure, including equipment, that enables inter-institutional communication and sharing of resources related to emerging information technologies, along with software and multimedia tools for curriculum innovation, evaluation, and implementation.

4. That NSF facilitate partnerships among engineering schools, among employers of engineering graduates, and among members of both groups, structured to offer incentives to each of the parties involved, that will: (a) form relationships to support the new paradigm for undergraduate engineering education; (b) provide transfer of knowledge among the participants; and (c) target lifelong learning and graduate engineering education.

5. That, in identifying opportunities for investment in engineering education reform, NSF, the Coalitions, and individual universities place significant emphasis on development and deployment of technologies and methodologies that enable individuals to "work smarter," i.e., to augment their ability to learn and create, both as students and as practicing engineers.

6. That NSF fund programs to enhance the academic stature of participation in systemic engineering education reform and change the faculty culture so that educational research and teaching are valued as scholarly activities and incorporated into the faculty reward system.

7. That NSF establish a committed steering group who will stay with the vision and process to stimulate implementation and institutionalization of systemic engineering education reform.

Next Steps

Successful implementation of this Action Agenda requires the active partnership of multiple institutions and groups. Next steps and the responsible entities include:

- **NSF Staff:** formulate programs to support the Action Agenda, including reallocation of funding as necessary.
- **The Engineering Deans Council and Individual Deans:** be strong, vocal advocates for the Action Agenda, enlisting the support of faculty leaders, key employers, and external visiting committees, and use resources at their disposal to encourage active participation in engineering education reform.
- **ABET:** continue its reform of engineering accreditation criteria and processes to encourage, and not inhibit, educational innovation.
- **NSF and Engineering Deans' Leadership:** identify and work with engineering employer groups to develop and refine industry/education partnerships to support the Action Agenda.
- **NSF:** establish the steering group identified in Recommendation 7 above.

Acknowledgment

We acknowledge with special thanks the inspiration, leadership, and support provided by Dr. Joseph Bordogna, NSF Assistant Director for Engineering. Warm thanks are also offered to Dr. Bordogna's staff, who handled all workshop arrangements cheerfully and effectively: Ms. Maxine Byrd, Secretary to the Assistant Director, Ms. Gloria Godwin, Administrative Clerk, and Ms. Deborah Young, Administrative Officer for the Engineering Directorate.

A large measure of the workshop's success resulted from outstanding efforts of the individual team leaders and recorders. Special thanks are due to Dr. Gretchen Kalonji, Dr. Don Kirk, Dr. George Peterson, and Dr. Tim Trick, who served as team leaders, and to the recorders, Dr. Alice Agogino, Dr. Kishan Baheti, Dr. John Hurt, and Dr. Marshall Lih.

Appendix A:

Selected Engineering Education Publications, 1985–1995

1. "Engineering Education and Practice in the United States," National Academy Press, 1985.
2. "Undergraduate Science, Mathematics, and Engineering Education," National Science Board, NSB 86-100, 1986.
3. "Quality of Engineering Education," Final Report of the Quality of Engineering Education Project, American Society for Engineering Education, September 1986.
4. "Engineering Education Answers the Challenges of the Future," Proceedings of the National Congress on Engineering Education, Accreditation Board for Engineering and Technology, Inc., November 1986.
5. "A National Action Agenda for Engineering Education," Report of an ASEE Task Force (E. E. David, Jr., Chair), American Society for Engineering Education, 1987.
6. "Workshop on Engineering - April 1988," Report of the NSF Disciplinary Workshops on Undergraduate Education, pp 51-55, NSF 89-3, National Science Foundation, 1989.
7. Karl Willenbrock *et al.*, "Imperatives in Undergraduate Engineering Education: Issues and Actions," Report of an NSF *Ad Hoc* Task Force, August 1989 ("the Belmont Conference").
8. "Education and Continuing Development of the Civil Engineer," Proceedings of an ASCE National Forum, 17-20 April 1990, American Society for Civil Engineers, 1990.
9. Roland W. Schmidt, Letter Report to E. W. Ernst of an NSF-Sponsored NAE Workshop on "Engineering, Engineers, and Engineering Education in the 21st Century," 9 May 1990.
10. "An Engineering Look Forward: New Decade, New Century, New Millennium," Proceedings of the 1990 ABET Annual Meeting, 17-18 October 1990, Accreditation Board for Engineering and Technology, Inc.
11. "America's Academic Future," Report of the Presidential Young Investigator Colloquium on U.S. Engineering, Mathematics, and Science Education for the Year 2010 and Beyond, NSF 91-150, National Science Foundation, 1992.
12. "Engineering Education Issues: Report on Survey of Opinions by Engineering Deans and Employers of Engineering Graduates on First Professional Degree," NSPE Professional Engineers in Education Sustaining University Program, NSPE Publication 3059, National Society of Professional Engineers, November 1992.
13. Joseph Bordogna, Eli Fromm, and Edward Ernst, "Engineering Education: Innovation Through Integration," Journal of Engineering Education, Vol 82, No. 1, pp 3-8 (1993)
14. J. Harris, Eugene M. DeLoatch, William R. Grogan, Irene C. Peden, and John R. Whinnery, "Journal of Engineering Education Round Table: Reflections on the Grinter Report," Journal of Engineering Education, Vol 83, No. 1, pp 69-94 (1994) (includes as an Appendix the Grinter Report, issued in September, 1955).
15. "Engineering Education for a Changing World," Report of a Joint Project of the ASEE Engineering Deans Council and Corporate Roundtable, American Society for Engineering Education, 1994.
16. "Industry 2000: Technical Vitality Through Continuing Education," Report of a workshop conducted by the IEEE Educational Activities Board in May 1994, Institute of Electrical and Electronics Engineers, Inc., 1995.
17. "Restructuring Engineering Education: A Focus on Change," Report of an NSF Workshop, NSF 95-65, National Science Foundation, 1995.
18. "Engineering Education: Designing an Adaptive System," Report of the NRC Board on Engineering Education, National Research Council, 1995.
19. John H. McMasters and James D. Lang, "Enhancing Engineering and Manufacturing Education: Industry Needs, Industry Roles," presented at the 1995 ASEE Annual Conference and Exposition, June 25-28 1995, American Society for Engineering Education.

Appendix B:

Workshop Process and Aggregate Recommendations

Workshop Process

The workshop participants met in plenary session for the first afternoon (July 11) and heard presentations that outlined the background and rationale for current engineering education reform initiatives. These presentations also emphasized the high degree of consensus among a broad range of stakeholders about the attributes needed by engineering graduates for effective participation in the 21st Century work force and the needed changes in the educational paradigm that will allow students to develop these attributes.

On the morning of the second day (July 12) participants were divided into four small groups, each charged to define an action agenda to implement the new paradigm in a timely manner, and to identify the change agents responsible for each action. At the start of the afternoon, participants were redivided among four new small groups, provided with all recommendations from the morning small group meetings, and asked to combine and refine these to produce a revised action agenda by the end of the day. That evening, the workshop and small group leaders discussed the recommendations and prepared a combined set for discussion by all participants on the following morning (July 13). The final plenary discussion produced recommendations about both *WHAT* should be accomplished by an action plan as well as *HOW* these results can be realized. The major part of the recommendations focused on *WHAT* NSF should do, either as direct action or as a stimulus for others, with anticipated responses from academe, industry, and the engineering professional societies.

Aggregate Workshop Recommendations

Recommendations for *WHAT* the Action Plan should seek to accomplish include a vision and goals for NSF and others, including engineering deans and faculties, professional societies, the National Academy of Engineering, industry, and private foundations.

I. NSF

A. NSF is strongly encouraged to continue to support the integration of education and research as enunciated in the four core strategies of its Strategic Plan.*
   1. *Develop intellectual capital.*
   2. *Strengthen the physical infrastructure.*
   3. *Integrate research and education.*
   4. *Promote partnerships.*

B. NSF needs collaboration across the Engineering, Mathematics and Physical Sciences, Education and Human Resources, and Computer and Information Sciences Directorates to support science, mathematics, engineering, and technology curriculum renewal.

C. NSF needs mechanisms whereby the structure and management of NSF programs are evaluated by their participants to enhance program effectiveness.

D. There must be consistency and continuity in Engineering Directorate leadership, vision, and implementation, particularly for matters related to education.

E. Fundamental structural changes are needed in the Engineering Education Coalitions program to enable existing Coalitions to serve as models for partnerships among engineering schools as well as to become more effective platforms for cultural change nationally. This will require a collaboration and a possible restructured cooperative relationship between the Coalitions leadership and the NSF. Fundamental changes may include:
   1. Expect new entities or alternative structures, and realignment of Coalitions, as possible outcomes.
   2. Build life cycle and transition strategies into the strategic plan of each Coalition.
   3. Develop consistent metrics for evaluation, including those that document the

*NSF in a Changing World: The National Science Foundation's Strategic Plan, Publication NSF 94-183, approved by the National Science Board, October 14, 1994, p. 3.

retention to graduation of underrepresented groups.

F. Objectives for new NSF programs include:
   1. Systemic, substantial, holistic curriculum reform:
      a) interdisciplinary, vertically integrated real design projects;
      b) approaches to enable students to learn how to "work smarter;"
      c) collaborations with colleges of arts and sciences, business, and medicine in curriculum development;
      d) couplings between engineering technology and engineering programs that emphasize complementary and evolving roles in the workplace.
   2. Bold experiments in the educational enterprise, including radically different academic organizational structures and programs for professional master's degrees.
   3. Development of metrics and assessment models for educational research and for teaching that will enhance the academic stature of these activities and:
      a) change the faculty/academic culture and faculty reward system;
      b) recognize educational research and teaching as valuable scholarly activities.

G. Facilitate new/improved industry/university partnerships and government laboratory/university partnerships to:
   1. Identify and produce case studies of successful collaborations.
   2. Form relationships that support the new paradigm for undergraduate engineering education.
   3. Provide two-way transfer of knowledge between universities, industry, and government laboratories.
   4. Target lifelong learning and graduate engineering education.

H. Stimulate organizational structures and pedagogical models to permit students to take responsibility for their education.

I. Encourage establishment of a database of information about curricular, pedagogical, organizational, and cultural reform in engineering education.

J. Establish a steering group of "true believers" who will stay with the vision and process to stimulate systemic engineering education reform.

II. Others

A. Engineering deans exercise leadership to engage a broad segment of faculty in the implementation of this Action Agenda for systemic reform.

B. Engineering faculties and deans re-emphasize quality teaching skills and interest as essential criteria for new faculty appointments.

C. Engineering faculties and deans structure engineering schools to be agile to meet changing technologies and societal needs.

D. Professional Societies and NAE provide more recognition of substantive contributions to engineering education in terms of awards, professional society fellowships, and NAE memberships.

E. Determine appropriate mechanisms for industry and private foundations to support the action plan for systemic reform.

Recommendations for HOW this vision and these goals can be realized include tasks both for NSF and other groups.

III. NSF

A. Clear statements from NSF that:
   1. Each research proposal must include a plan illustrating how it will contribute to the overriding educational mission of the university.
   2. Each education proposal must incorporate a plan for implementation and institutionalization, including a commitment by the university administration to continue successful programs after NSF funding ends.

B. Proposals to NSF for educational research:
   1. Must include a scholarly, rigorous approach to research in education.
   2. Must include clear plans for evaluation and self-assessment.
   3. Must include meaningful industrial linkages where appropriate. All proposals should include a statement that industry involvement has been considered, is/is not judged appropriate, and justification for the decision.

4. Should be reviewed by panels that include specialists in educational innovation and formative educational assessment.
5. May include the following formats spanning a breadth of potential collaborations, for example:
   a) individual grants;
   b) team/cross-disciplinary grants;
   c) Coalitions/centers;
   d) partnerships with industry, colleges of education, etc.

C. Possible restructuring of the Engineering Education Coalitions could include:
1. Changes in the membership of the Coalitions.
2. Supplemental funds for cross-coalition targets of opportunity.
3. Supplemental funds for non-coalition schools to implement and refine Coalition successes.
4. Plans to transition meritorious Coalition programs with potential nationwide impact to the broader engineering community.

D. Grant Opportunities for Academic Liaison With Industry (GOALI):
1. Carefully assess how well this program is working.
2. Publicize the program in the industrial sector to encourage further industry/academic collaboration.

E. New Programs for NSF Funding:
1. Connecting the workshop group to the implementation of the Action Agenda.
2. Comprehensive, systemic restructuring of all undergraduate engineering curricula, along with the supporting organization and technologies, at a single institution (possibly funded jointly by several agencies).
3. Projects to explore distributed, collaborative resource development for shared information/communication infrastructure and use (this includes access to equipment related to emerging competitive technologies, along with software and multimedia tools for collaborative curriculum development, evaluation, and implementation).
4. Transfer of successful educational programs to other institutions and transfer of people between universities via visits, workshops, etc.
5. Collaborations between colleges of engineering and education for development of effective teaching and learning strategies for undergraduate education and for curriculum development for pre-college teachers.
6. Grants for:
   a) early faculty-teacher mentorships;
   b) engineering workshops for pre-college guidance counselors and science/math teachers;
   c) propagation of successful pre-college engineering programs.

IV. Other Initiatives Include:

A. Establishing an engineering education roundtable with industry, professional society, and private foundation participation.

B. Convening a meeting of university presidents and provosts with high level industrial representation to articulate and discuss the transformed NSF vision of integrating education and research.

C. Involving a broader segment of engineering employers, including small industries and non-traditional employers, in partnerships with academe, government entities, NAE, professional societies and ABET to provide input and intellectual resources to engineering education reform.

D. Forming regional partnerships to coordinate and evaluate K-14 outreach programs, under the leadership of engineering deans working with their own industry boards and professional educators.

Appendix C:

Background Materials

Systematic Engineering Education Reform: An Action Agenda

Why Are We Here?

This workshop is about getting on with it—"it" being the matter we have all heard, talked, and read about so much in recent years—workable, systemic, long-term change in the way undergraduate engineering education is carried out. You are here because you represent industry, academe, government, professional societies, and accreditors and because you are innovators, enablers, implementors, and committed national team members whose insights and shared experiences can come together in a plan for action to guide future NSF investment.

What Does NSF Want and Why?

NSF's prime focus is to enable the nation's capacity to perform through a holistic investment in fundamental research and education. The Foundation has demonstrated its willingness to support ventures in areas that are riskier than those that universities or industry are willing to underwrite alone. The Engineering Education Coalitions are good examples, as are the Engineering Research Centers. The Coalitions began as experimental ventures, each committed to its own, self-selected approach to the achievement of common goals—curriculum innovation; creative new approaches to the delivery of undergraduate engineering education; a substantial increase in the number of engineering degrees awarded to members of underrepresented groups—all focused on creating an integrative undergraduate engineering experience. There are now eight Coalitions involving 60 institutions. All engage in outreach to high schools and two-year colleges.

Undergraduate curricula reside in the educational spectrum between high school and graduate studies or a career coupled with lifelong learning; in some cases, a portion of the curriculum is delivered through a two-year college. A successful vision for systemic reform demands a clear view of this spectrum and of the continuity required to implement an action agenda for the entire undergraduate experience.

The Coalitions, together with other educational innovations sponsored by NSF in recent years, have already produced valuable information about some approaches that work. Examples are integration of design concepts into the curriculum at all levels; horizontal integration across engineering, the basic sciences, mathematics, and humanities; and a sea change in faculty perspective, away from the traditional delivery of information and toward the development of students as emerging engineering professionals and life-long learners. Some approaches tried by various Coalitions have not worked and have been changed or abandoned. NSF understands risk and does not expect that all experiments will succeed. On the other hand, NSF will not support continuation of unsatisfactory approaches just because they have been created.

What Will NSF Do With the Results of Our Effort?

Lasting, systemic change requires that successful innovations be institutionalized so that faculty come to view them as the norm, a task substantially more difficult than developing the innovations themselves. The Engineering Directorate leadership is asking for your best advice in defining how this task should be accomplished, what should be done next, who should be the agents of change for implementing the various steps of the action agenda, and how NSF leadership and investment can best be directed to support this agenda.

Engineering Education for the 21st Century: Why, What, How?

Why Change Now? Challenges to 21st Century Engineers

- Intelligent technology offers greater creative opportunity; ability to work smarter;
- Global workplace demands multi-cultural skills; expanding social infrastructure needs talent for complexity;
- Massively-integrated populations place environment, health, and safety at the front end of design;
- Eclectic, constantly changing work environment calls for astute interpersonal skills;
- Changing demographics; success in serving a diverse customer base requires a diverse workforce.

A Change to What? Characteristics of 21st Century Engineering Education

Broad structural and cultural, rather than incremental, changes in undergraduate engineering education are required. As the focus for this change, graduates must be educated to:

- Understand the functional core of the engineering process;
- Analyze and synthesize; formulate problems and solve them; become adept at group problem-solving strategies;
- Think across disciplines (lateral thinking) as well as in disciplinary depth (vertical thinking);
- Communicate ideas effectively to diverse groups, including non-engineers; act both independently and as a team member;
- Recognize, contribute to, and enjoy the relationship of the engineering enterprise to the social/economic/political context in which they live and work;
- Develop the motivation, knowledge base, and intellectual capability for career-long learning.

How to Change? Characteristics of 21st Century Education

To achieve these results, engineering education must:

- Place primary emphasis on the development of students as emerging professionals;
- Make the study of engineering attractive, exciting, and fulfilling throughout; seriously engage students in engineering from the day they matriculate;
- Make active learning the predominant engineering student learning mode;
- Draw engineering faculty to a dedicated investment in the teaching of undergraduates;
- Increase the diversity of student academic backgrounds and the numbers of women and underrepresented minorities who succeed in engineering study;
- Give students an appreciation for the realities of engineering practice through regular, well-planned interaction with industry.

The Action Agenda: Challenges and Questions

The Action Agenda must respond to the challenges and questions implicit in realizing the new paradigm for engineering education in the 21st Century. These challenges include:

Changing the Culture on Campus for Engineering Education

We must change the usual engineering school academic culture. *How can we:*

- Redefine faculty roles to support the new paradigm?
- Realize a faculty reward and recognition system that supports the redefined roles?
- Encourage faculty to invest their efforts in engineering education?
- Enable students to *work smarter* and be more involved in their education?

- Infuse CQI concepts into both educational process and content?
- Adapt college, department, and other institutional structures to encourage the changes needed?

Resources: Human, Financial, and Other

Engineering education today is highly resource-intensive, requiring significant investments in faculty, support staff, and facilities. Hence, innovative use of resources and maximum leveraging of multiple sources of support will be critical to successful implementation and institutionalization of the new paradigm. *How can we:*

- Leverage multiple sources of support to provide the resources needed for 21st Century engineering education?
- Form effective, resource-sharing partnerships among engineering schools?
- Structure engineering school partnerships with industry to offer appropriate incentives to both parties?
- Structure future NSF investment most effectively to stimulate and encourage broad-based change in engineering education?

Maintaining the Change

Beyond realizing the engineering education paradigm for the 21st Century, we must sustain the change so that the new paradigm becomes the norm. *How can we:*

- Help institutions maintain the changes they make to realize the new paradigm?
- Sustain, on a long term basis, enhanced student exposure to the world of engineering practice?
- Support ABET efforts to encourage and sustain the new paradigm?

Appendix D:

Workshop Schedule

Systemic Engineering Education Reform: An Action Agenda

A Workshop Sponsored by the National Science Foundation Engineering Directorate Arlington Renaissance Hotel, Arlington, VA, July 11-13, 1995

Schedule

Day I: Tuesday, July 11

1:00 pm	Introduction	Ernst/Peden
1:10 pm	Perspective: How We Got Here	Willenbrock
1:30 pm	Perspective: Engineering Employer Needs	McMasters
2:00 pm	Perspective: Engineering Education for 2020 and Beyond	Agogino
2:30 pm	The Players for Transforming Engineering Education: Potential Roles	Phillips
3:00 pm	Break	
3:30 pm	The NSF Engineering Education Coalitions Program: Lessons Learned and Potential for Change	Prados
4:00 pm	What Is an Action Plan? Issues To Be Addressed	Peden/Ernst
4:30 pm	Challenge to Action	Bordogna
5:00 pm	Adjourn for Day I	
Evening	Workshop and Small Group Leaders Meet to Resolve Any Remaining Questions on Small Group Operation	

Day II: Wednesday, July 12

8:30 am	Instructions to Teams	Ernst/Peden
8:40 am	Brainstorm; Evaluate Options	Individual Teams
10:00 am	Break	
10:30 am	Converge to Preliminary Recommendations	Individual Teams
12:00 noon	Lunch; Recorders Prepare Recommendation Summaries	
1:30 pm	Share Recommendation Summaries Among Teams; Questions for Clarification Only	Peden/Ernst
2:00 pm	Evaluate Preliminary Recommendations	Reconstituted Teams
3:00 pm	Break	
3:30 pm	Converge to Revised Recommendations	Reconstituted Teams

5:00 pm	Adjourn for Day II
Evening	Workshop and Small Group Leaders Meet to Adjust Day III Strategy, As Needed

Day III: Thursday, July 13, 1995

8:00 am	All Participants Meet in Plenary Session to Develop Draft Action Plan; Recorders Share Revised Recommendations; Participants Discuss and Prioritize Recommendations, To Include: • What Needs To Be Done • Commitment to Follow-Up Action by Specific Groups • Guidance for NSF Leadership and Investment
9:30 am	Break
10:00 am	Continue Plenary Discussion
12:00 noon	Workshop Adjourns

Appendix E:

Workshop Participants

Dr. Alice M. Agogino
Director, Synthesis Coalition
Assoc. Dean, College of Engineering
University of California, Berkeley
5136 Etcheverry Hall
Berkeley, CA 94720
ph: (510) 642-6450 fax: (510) 643-5599
e-mail: aagogino@euler.berkeley.edu

Dr. Radhakishan S. Baheti
Program Director
Electrical and Communications Systems Division
National Science Foundation
4201 Wilson Boulevard, Suite 675
Arlington, VA 22230
ph: (703) 306-1339 fax: (703) 306-0305
e-mail: rbaheti@nsf.gov

Dr. Eleanor Baum
President, American Society for Engineering Education
Dean of Engineering
The Cooper Union
51 Astor Place
New York, NY 10003
ph: (212) 353-4285 fax: (212) 353-4341
e-mail: baum@cooper.edu

Dr. Joseph Bordogna
Assistant Director for Engineering
National Science Foundation
4201 Wilson Boulevard, Suite 505
Arlington, VA 22230
ph: (703) 306-1300 fax: (703) 306-0289
e-mail: jbordogn@nsf.gov

Dr. Harold D. Brody
Director, Engineering Academy of Southern New England (EASNE Coalition)
Dean of Engineering
University of Connecticut
Storrs, CT 06269-3237
ph: (860) 486-2223 fax: (860) 486-0318
e-mail: brody@eng2.uconn.edu

Mr. Ronald Carle
Manager of Projects
Stone & Webster, Inc.
250 W. 34th Street
New York, NY 10019
ph: (212) 290-7438 fax: (212) 290-7575
e-mail: carle9999@aol.com

Dr. David C. Chang
President
Polytechnic University
6 Metro Tech Center
Brooklyn, NY 11201
ph: (718) 260-3500 fax: (718) 260-3755
e-mail: chang@poly.edu

Mr. Marcus A. Clarke
Manager., External & Govt. Education & Training Relations
Ford Motor Company, World Headquarters
The American Road, Room 306
Dearborn, MI 48121
ph: (313) 322-9231 fax: (313) 845-5765
e-mail:

Mr. Bruce C. Coles
Chairman, President, and CEO
Stone & Webster, Inc.
250 W. 34th Street
New York, NY 10019
ph: (212) 290-7494 fax: (212) 290-7575
e-mail:

Dr. Denice D. Denton
Professor of Electrical and Computer Engineering
University of Wisconsin, Madison
1415 Johnson Drive
Madison, WI 53796
ph: (608) 263-2354 fax: (608) 265-2614
e-mail: denton@janus.ece.wisc.edu

Dr. Edward W. Ernst
Allied Signal Professor
University of South Carolina
Swearingen Engineering Center
Columbia, SC 29208
ph: (803) 777-7990 fax: (803) 777-8045
e-mail: ernst@ece.scarolina.edu

Dr. Karen Frair
Foundation Coalition
University of Alabama
Box 870200
Tuscaloosa, AL 35487-0200
ph: (205) 348-4090 fax: (205) 348-4088
e-mail: kfrair@ua1vm.ua.edu

Dr. Eli Fromm
Director, Gateway Coalition
Vice Provost, Graduate Studies & Research
Drexel University
32nd and Chestnut Streets
Philadelphia, PA 19104
ph: (215) 895-2201 fax: (215) 895-1056
e-mail: fromme@duvm.ocs.drexel.edu

Mr. Jerrier A. Haddad
President, Accreditation Board for Engineering & Technology, Inc.
Vice President, IBM - Retired
162 Macy Road
Briarcliff Manor, NY 10510
ph: (814) 941-7016 fax: (814) 941-4868
e-mail: jahaddad@aol.com

Dr. Leo E Hanifin
Director, Greenfield Coalition
Dean, College of Engineering and Science
University of Detroit Mercy
P. O. Box 19900
Detroit, MI 48219
ph: (313) 993-1216 fax: (313) 993-1187
e-mail: hanifinl@udmercy.edu

Dr. John C. Hurt
Program Director
Engineering Education and Centers Division
National Science Foundation
4201 Wilson Boulevard, Suite 585
Arlington, VA 22230
ph: (703) 306-1380 fax: (703) 306-0326
e-mail: jhurt@nsf.gov

Dr. Gretchen Kalonji
Kyocera Professor of Materials Science & Engineering
University of Washington
Roberts Hall, FB-10
Seattle, WA 98195
ph: (206) 543-1115 fax: (206) 543-3100
e-mail: kalonji@mbinguni.mats.washington.edu

Dr. Donald E. Kirk
Dean of Engineering
San Jose State University
San Jose, CA 95192-0080
ph: (408) 924-3800 fax: (408) 924-3818
e-mail: dkirk@isc.sjsu.edu

Ms. Caryn Korshin
Exxon Education Foundation
225 E. Carpenter Freeway
Irving, TX 75062
ph: (214) 444-1104 fax: (214) 444-1405
e-mail: caryn.g.korshin@exxon.sprint.com

Dr. Kenneth R. Laker
Vice President for Educational Activities, Institute of Elecrical and Electronics Engineers, Inc.
Professor of Electrical Engineering
University of Pennsylvania
Philadelphia, PA 19104-6314
ph: (215) 898-5340 fax: (215) 573-2068
e-mail: laker@ee.upenn.edu

Dr. Peter Y. Lee
Dean of Engineering
California Polytechnic State University
San Luis Obispo, CA 93407
ph: (805) 756-2131 fax: (805) 756-6503
e-mail: di008@oasis.calpoly.edu

Dr. Marshall M. Lih
Director, Engineering Education & Centers Division
National Science Foundation
4201 Wilson Boulevard, Suite 585
Arlington, VA 22230
ph: (703) 306-1380 fax: (703) 306-0326
e-mail: mlih@nsf.gov

Dr. John H. McMasters
Senior Principal Engineer, Aerodynamics Engineering
Boeing Commercial Airplane Group
P. O. Box 3707, Mail Stop 6H-LR
Seattle, WA 98124-2207
ph: (206) 237-1542 fax: (206) 237-4831

Mr. Lawrence W. Milas
President
F. W. Olin Foundation, Inc.
780 Third Avenue, Suite 3403
New York, NY 10017-7090
ph: (212) 832-0508 fax: (212) 935-9083

Dr. Venkatesh Narayanamurti
Dean of Engineering
University of California, Santa Barbara
Santa Barbara, CA 93106
ph: (805) 893-3141 fax: (805) 893-8124
e-mail: venky@engineering.ucsb.edu

Dr. Irene C. Peden
Professor Emerita
University of Washington
8752 Sand Point Way
Seattle, WA 98115
ph: (206) 527-9734 fax: (206) 527-1938
e-mail: ipeden@maxwell.ee.washington.edu

Dr. George C. Peterson
Executive Director
Accreditation Board for Engineering & Technology, Inc.
111 Market Place, Suite 1050
Baltimore, MD 21202
ph: (410) 347-7710 fax: (410) 625-2238
e-mail: gpeterson@abet.ba.md.us

Dr. Winfred M. Phillips
President-Elect, American Society for Engineering Education
Board of Governors, American Society of Mechanical Engineers
Dean of Engineering
University of Florida
Gainesville, FL 32611-6550
ph: (904) 392-6000 fax: (904) 392-9673
e-mail: wphil@engnet.ufl.edu

Dr. John W. Prados
Senior Education Associate
Engineering Education and Centers Division
National Science Foundation
4201 Wilson Boulevard, Suite 585
Arlington, VA 22230
ph: (703) 306-1380 fax: (703) 306-0290
e-mail: jprados@utk.edu

Dr. Martin R. Ramirez
Professor, College of Engineering & Science
University of Detroit Mercy
4001 W. McNichols Road
Detroit, MI 48219
ph: (313) 993-1193 fax: (313) 993-1146
e-mail: ramirez@udmercy.edu

Dr. Linton G. Salmon
Assoc. Dean, College of Engineering & Technology
Brigham Young University
270 CB
Provo, UT 84602
ph: (801)378-4327 fax: (801) 378-5705
e-mail: salmon@ee.byu.edu

Dr. Chalmers F. Sechrist
Program Director
Division of Undergraduate Education
National Science Foundation
4201 Wilson Boulevard, Suite 835
Arlington, VA 22230
ph: (703) 306-1667 fax: (703) 306-0445
e-mail: csechris@nsf.gov

Dr. Earnest T. Smerdon
Chair, Engineering Deans Council, American Society for Engineering Education
Dean, College of Engineering & Mines
University of Arizona
Tucson, AZ 85721
ph: (520) 621-6594 fax: (520) 621-2232
e-mail: smerdon@arizona.edu

Dr. Jacqueline Sullivan
Director, Center for Integrated Teaching & Learning
University of Colorado
ENG Center, Rm. CE 1.02
Boulder, CO 80309-0421
ph: (303) 492-3972 fax: (303) 492-1347
e-mail: sully@cadswes.colorado.edu

Dr. Timothy N. Trick
Professor & Head, Electrical & Computer Engineering
University of Illinois
1406 West Green Street
Urbana, IL 61801
ph: (217) 333-2301 fax: (217) 244-7075
e-mail: trick@ece.uiuc.edu

Dr. John Vander Sande
Interim Dean of Engineering
MIT
77 Massachusetts Avenue, 1-206
Cambridge, MA 02139
ph: (617) 253-3292 fax: (617) 253-8549
e-mail: maj@eagle.mit.edu

Dr. M. Lucius Walker, Jr.
Director, Engineering Coalition for Excellence in Education and Leadership (ECSEL)
Professor, School of Engineering
Howard University
Washington, DC 20059
ph: (202) 806-6565 fax: (202) 462-1810
e-mail: walker@echo.umd.edu

Mr. Donald Weinert
Executive Director Emeritus
National Society of Professional Engineers
8121 Dunsinane Court
McLean, VA 22102
ph: (703) 356-6851 fax: (703) 356-3130
e-mail: dweinert@nspe.org

Dr. F. Karl Willenbrock *(Deceased)*
Consultant
1740 New Hampshire Ave., NW, Unit E
Washington, DC 20009

Dr. J. Richard Williams
Director, Southern California Coalition for Education in Manufacturing Engineering (SCCEME)
Dean of Engineering, California State University—Long Beach
1250 Bellflower Boulevard
Long Beach, CA 90840
ph: (310) 985-5190 fax: (310) 985-8736
e-mail: jrw@engr.csulb.edu

Dr. David N. Wormley
Dean of Engineering
The Pennsylvania State University
101 Hammond Building
University Park, PA 16802
ph: (814) 865-7537 fax: (814) 863-4749
e-mail: dnwdo@engr.psu.edu

Dr. James T. P. Yao
Chair, Steering Committee, 1995 American Society of Civil Engineers Education Conference
Professor of Civil Engineering
Texas A&M University
College Station, TX 77843-3136
ph: (409) 845-1958 fax: (409) 845-6554
e-mail: jtpyao@tamu.edu

Dr. Carl F. Zorowski
Director, Southeastern University and College Coalition for Engineering Education (SUCCEED)
North Carolina State University
Raleigh, NC 27695-7901
ph: (919) 515-6597 fax: (919) 515-7685
e-mail: carl_zorowski@ncsu.edu

GETTING NSF INFORMATION AND PUBLICATIONS

The National Science Foundation (NSF) has several ways for the public to receive information and publications. Electronic or printed copies of the NSF telephone directory, abstracts of awards made since 1989, and many NSF publications are available as described below. To access information electronically, there is no cost to you except for possible phone and Internet access charges. Choose the method of access that matches your computer and network tools. For general information about Internet access and Internet tools, please contact your local computer support organization.

WORLD WIDE WEB: NSF HOME PAGE

The World Wide Web (WWW) system makes it possible to view text material as well as graphics, video, and sound. You will need special software (a "web browser") to access the NSF Home Page. The URL (Uniform Resource Locator) is ***http://www.nsf.gov/.***

INTERNET GOPHER

The Internet Gopher provides access to information on NSF's Science and Technology Information System (STIS) through a series of menus. To access the Gopher, you need Gopher client software; the NSF Gopher server is on port 70 of ***stis.nsf.gov***.

ANONYMOUS FTP (FILE TRANSFER PROGRAM)

Internet users who are familiar with FTP can easily transfer NSF documents to their local system for browsing and printing. The best way to access NSF information is to first look at the index (file name: **index.txt**). From the index, you can select the files you need. FTP instructions are:

- FTP to ***stis.nsf.gov***.
- Enter **anonymous** for the user name, and your e-mail address for the password.
- Retrieve the appropriate file (i.e., **filename.ext**).

E-MAIL (ELECTRONIC-MAIL)

To get documents via e-mail, send your request to the Internet address ***stisserve@nsf.gov***. The best way to find NSF information is to request the index. Your e-mail message should read: **get index.txt**. An index with file names will be sent to you. However if you know the file name of the document you want, your e-mail message should read: **get <filename.ext>**.

E-MAIL MAILING LISTS

NSF maintains several mailing lists to keep you automatically informed of new electronic publications. To get descriptions of the mail lists and instructions for subscribing, send your request to: ***stisserve@nsf.gov***. Your message should read: **get stisdirm.txt**.

ON-LINE STIS

NSF's Science and Technology Information System (STIS) is an electronic publications dissemination system available via the Internet (telnet to ***stis.nsf.gov***); you will need a VT100 emulator. The system features a full-text search and retrieval software (TOPIC) to help you locate the documents. Login as **public** and follow the instructions on the screen.

To get an electronic copy of the "STIS USERS GUIDE," NSF 94-10, send an e-mail request to: ***stisserve@nsf.gov***. Your message should read: **get NSF9410.txt**. For a printed copy of the "STIS USERS GUIDE," see instructions "How To Request Printed NSF Publications."

NON-INTERNET ACCESS VIA MODEM

If you do not have an Internet connection, you can use remote login to access NSF publications on NSF's on-line system, STIS. You need a VT100 terminal emulator on your computer and a modem.

- Dial **703-306-0212**,
- choose 1200, 2400, or 9600 baud,
- use settings 7-E-1, and
- login as **public** and follow the on-screen instructions.

HOW TO REQUEST PRINTED NSF PUBLICATIONS

You may request printed publications in the following ways:

- send e-mail request to: ***pubs@nsf.gov***
- fax request to: **703-644-4278**
- for phone request, call: **703-306-1130** or Telephonic Device for the Deaf (TDD **703-306-0090**)
- send written request to:

  NSF Forms and Publications Unit
  4201 Wilson Boulevard
  Room P-15
  Arlington, VA 22230

When making a request, please include the following information:

- NSF publication number;
- number of copies; and
- your complete mailing address.

QUESTIONS ABOUT NSF PUBLICATIONS, PROGRAMS, ETC.

Contact the NSF Information Center if you have questions about publications, including publication availability, titles, and numbers. The NSF Information Center maintains a supply of many NSF publications for public use. You may:

- visit the NSF Information Center, located on the second floor at 4201 Wilson Blvd., Arlington, Virginia.; or
- call the NSF Information Center at **703-306-1234**; or **703-306-0090** for TDD; or
- send e-mail message to ***info@nsf.gov***.

QUESTIONS ABOUT THE ELECTRONIC SYSTEM

Send specific, system-related questions about NSF electronic publication services that are not answered in this flyer, to ***webmaster@nsf.gov*** or call **703-306-0214** (voice mail).

NATIONAL SCIENCE FOUNDATION
ARLINGTON, VA 22230

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE $300

RETURN THIS COVER SHEET TO ROOM P35 IF YOU DO NOT WISH TO RECEIVE THIS MATERIAL ☐ , OR IF CHANGE OF ADDRESS IS NEEDED ☐ , INDICATE CHANGE INCLUDING ZIP CODE ON THE LABEL (DO NOT REMOVE LABEL).

BULK RATE
POSTAGE & FEES PAID
National Science Foundation
Permit No. G-69

00167149 MIS500
ERIC/CSMEE
1929 KENNY ROAD
COLUMBUS OH 43210-1080

NSF 96-63 (new)

BEST COPY AVAILABLE